

EdGCM: Educational Global Climate Modeling



Tools for Training the Climate Change Generation

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July 30, 2013

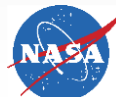
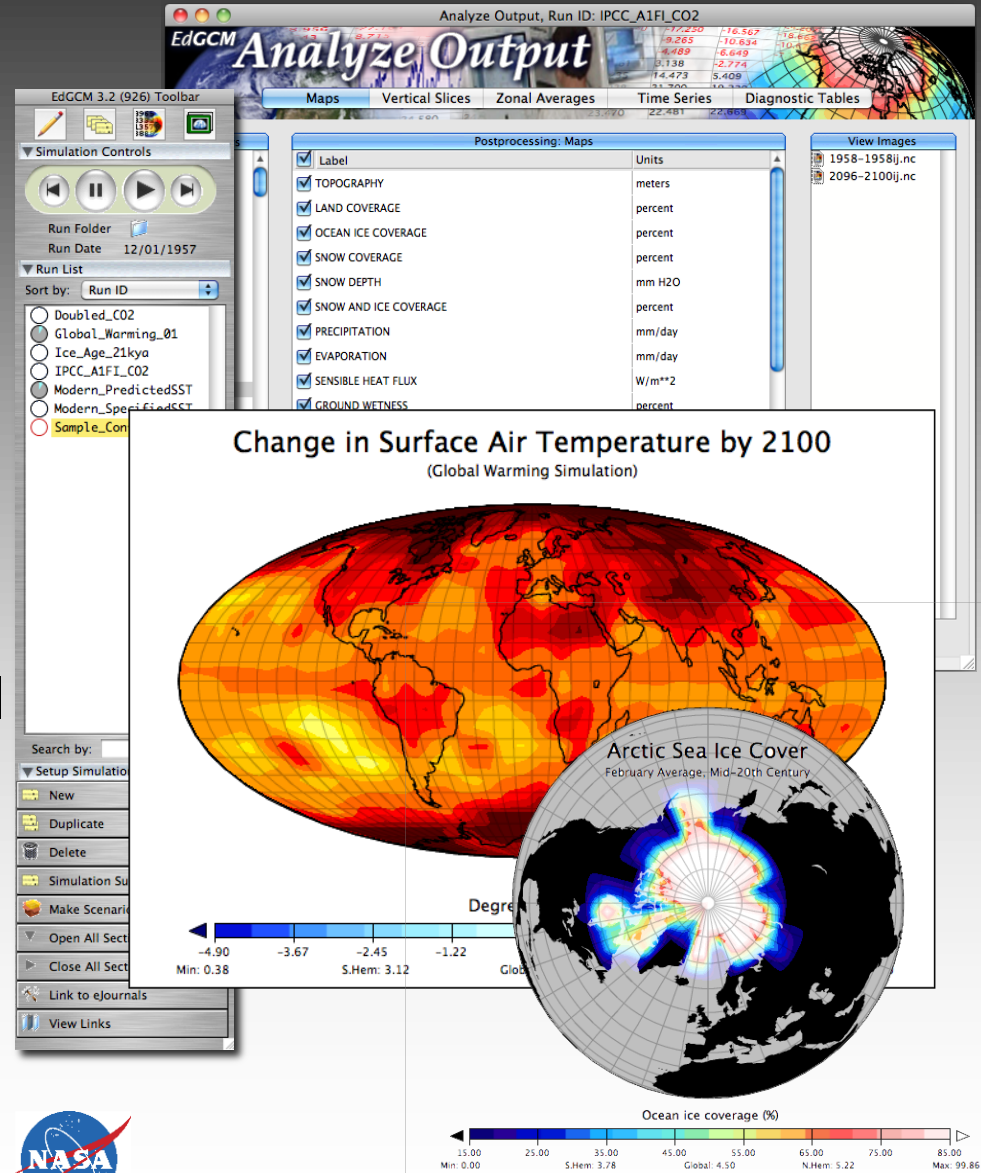


Educational Global Climate Modeling

The world is in your hands.



- Run a real NASA climate model
- Create your own simulations
- Make maps and plots
- Hundreds of climate variables
- Past or Future climates
- Mac or PC
- <http://edgcm.columbia.edu>



The Educational Global Climate Modeling Project



Project Objectives

- Allow teachers and students to use a genuine research version of NASA global climate model on accessible computers (desktop and laptop)
- Encourage students to participate in the full scientific process
 - Design experiments
 - Setup and run computer simulations
 - Analyze data
 - Communicate results

The Educational Global Climate Modeling Project



Project Objectives

- Enhance collaborations between schools, universities, national labs, and the private sector so students become familiar with the role of teamwork in scientific research.
- ...and by doing the above demystify how scientists forecast climate change.



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in

Seinfeld's Diner

Future Climate Change: Basis of Understanding



James Hansen, 1988

1. **Earth's Climate History**
2. **On-Going Global Changes**

On-Going Global Change: Coming Soon to a Community Near You



Future Climate Change: Basis of Understanding



James Hansen, 1988

1. Earth's Climate History
2. On-Going Global Changes
3. **Global Climate Models**
(note: modeling #3, but aids other two)

Climate Change Intelligence

GCMs are the primary tools used to supply climate change forecasts. They help us study the physical processes of climate change, predict its impacts, and evaluate mitigation and adaptation strategies.

Global Climate Model

Atmosphere



Oceans



Land Surface



Cryosphere

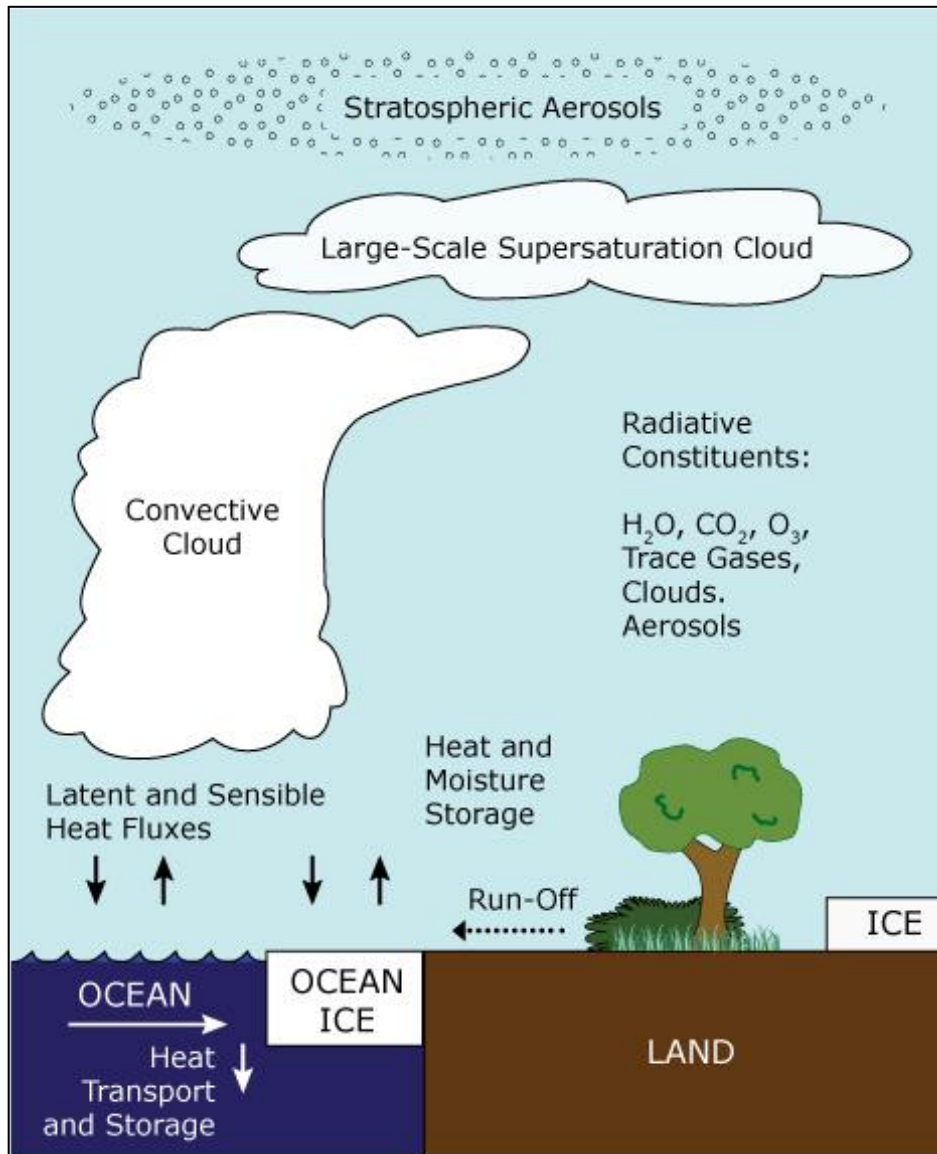


Tools of the Trade: Global Climate Models



- 這是“質量守恆定律”在中國
- 這是“節約能源”寫在中國
- 這是“動量守恆”寫在中國
- 這是“保護水分”寫在中國
- 這是“狀態方程”寫在中國

Physical Processes Simulated by GCMs



- Seasonal and Diurnal Cycles
- Latent and Sensible Heat Fluxes
- Clouds and Convection
- Greenhouse Gases
- Evaporation & Precipitation
 - snow
- Aerosols
- Ground Hydrology
 - soil moisture, run-off
- Ocean Heat Storage & Transport
- Ocean Circulation
- Atmospheric Chemistry
- Carbon Cycle
- Dynamic Vegetation
- Dynamic Ice Sheets

GCMs were predicted to be in common
use by now...

“...Very soon it will be possible to run a GCM on a laptop
computer.”

“GCMs will begin running on workstations in high
schools, and possibly elementary schools. They may even
be running in the offices of congressman.”

Dr. David Randall

Bulletin of the American Meteorological Society, 1996

...but there were stumbling blocks

What is a GCM? ...a computer program

Global_Warming_Sim2.R Model II 8/24/2000

Owner: Mark Chandler, m.chandler@nasa.gov

Group: Paleoclimate Group

This experiment simulates the climate of the snowball earth period of the Neoproterozoic Period in geologic history.

Object modules:

MainC9 DiagC9 RadC9

C** INITIALIZE SOME ARRAYS AT THE BEGINNING OF SPECIFIED DAYS

fName = './prt'//JMNTN0(1:3)//CYEAR//'.prt'//LABEL1(

IF(JDAY.NE.32) GO TO 294

JEQ=1+JM/2

DO 292 J=JEQ,JM

DO 292 I=1,IM

292 TSFREQ(I,J,1)=JDAY

JEQM1=JEQ-1

How does one learn to use a GCM?

23=V8X10_600Ma

26=Z8X101_600Ma

21=RTAU.G25L15

22=RPLK25

29=Snowball_Earth_Regions

Label and Namelist:

Global_Warming_Sim2 (Transient increase in CO2)

&INPUTZ

TAUI=10176.,IYEAR=1900,

KOCEAN=1, SRCOR=.95485638151,

S0X=1.,CO2=.31746031746031,

USET=0.,TAUE=35040.,USESLEP=-12.,

ISTART=3,KCOPY=2,NDPRNT=-1,TAUE=95616.

295 TSFREQ(I,J,1)=JDAY

C**** INITIALIZE SOME ARRAYS AT THE BEGINNING OF EACH DAY

296 DO 297 J=1,JM

DO 297 I=1,IM

TDIURN(I,J,1)=1000.

TDIURN(I,J,2)=-1000.

TDIURN(I,J,6)=-1000.

PEARTH=FDATA(I,J,2)*(1.-FDATA(I,J,3))

IF(PEARTH.GT.0.) GO TO 297

TSFREQ(I,J,1)=365.

TSFREQ(I,J,2)=365.

297 CONTINUE

Unix Scripts

Fortran Code

Computing Resources and Climate Models

Rule of thumb:
10X more CPU
doubling of
on

$8^{\circ} \times 10^{\circ}$

IPCC

$4^{\circ} \times 5^{\circ}$

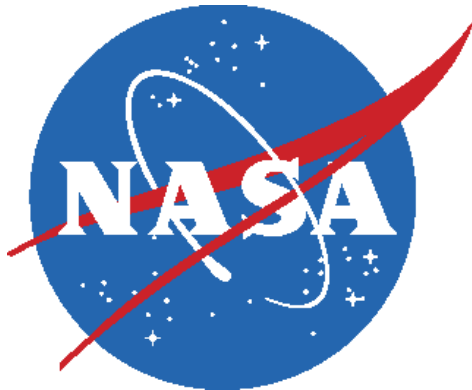


2001, 2007
IPCC AR3, AR4

2014
IPCC AR5

What is *EdGCM*?

- A GLOBAL CLIMATE MODEL
The NASA/GISS GCM Model II
- A GRAPHICAL USER INTERFACE
Wrapped around the global climate model



NASA Goddard Institute for Space Studies
Global Climate Modeling Program
www.giss.nasa.gov



Columbia University, EdGCM Project
Center for Climate Systems Research
edgcm.columbia.edu

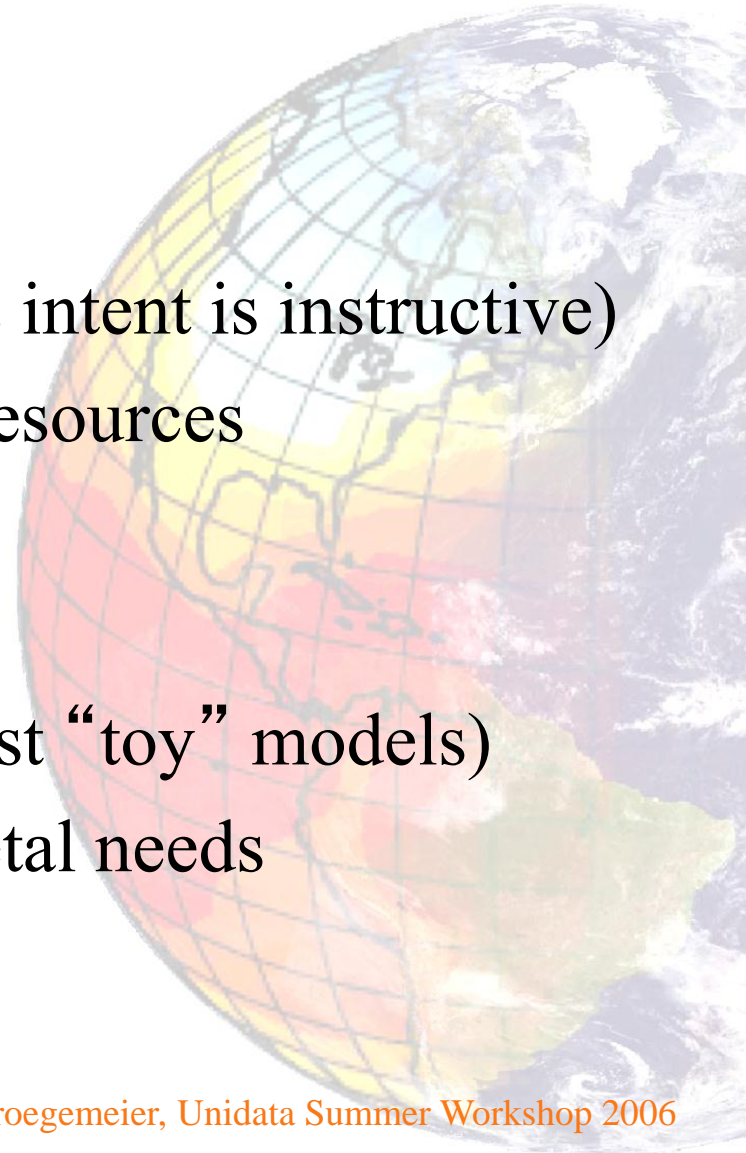
Other Computer Code Wrappers



Democratization of Global Climate Modeling

Tools for non-specialists must be:

- ▶ Highly intuitive
- ▶ Free of jargon (except where its intent is instructive)
- ▶ Usable on existing computing resources
- ▶ Free (or at least inexpensive)
- ▶ Responsive support
- ▶ Applicable to real world (not just “toy” models)
- ▶ Tied to current events and societal needs



Set up, Run and Organize a GCM

The image displays a collage of various EdGCM software interfaces, illustrating the workflow for setting up, running, and organizing a Global Climate Model (GCM) simulation.

EdGCM 3.2 (926) Toolbar: Features simulation controls (play, pause, stop, reset) and a run list. The run list includes options like Doubled_CO2, Global_Warming_01, Ice_Age_21kya, IPCC_A1FI_CO2, Modern_PredictedSST, Modern_SpecifiedSST, and Sample_Control_Run.

Setup Simulation, Run ID: Global_Warming_01: A window for configuring simulation parameters. It includes sections for General info (Run ID, Project ID, Run label, Comments), Input files, Ocean model, Diagnostic output, and Forcings (Greenhouse gases, Solar, Orbit, CO2 trend, N2O trend).

Simulation Library: A table listing various simulation runs with columns for Run ID, Label, Date, and Owner. The table includes runs like Doubled_CO2, Global_Warming_01, Ice_Age_21kya, IPCC_A1FI_CO2, Modern_PredictedSST, Modern_SpecifiedSST, and Sample_Control_Run.

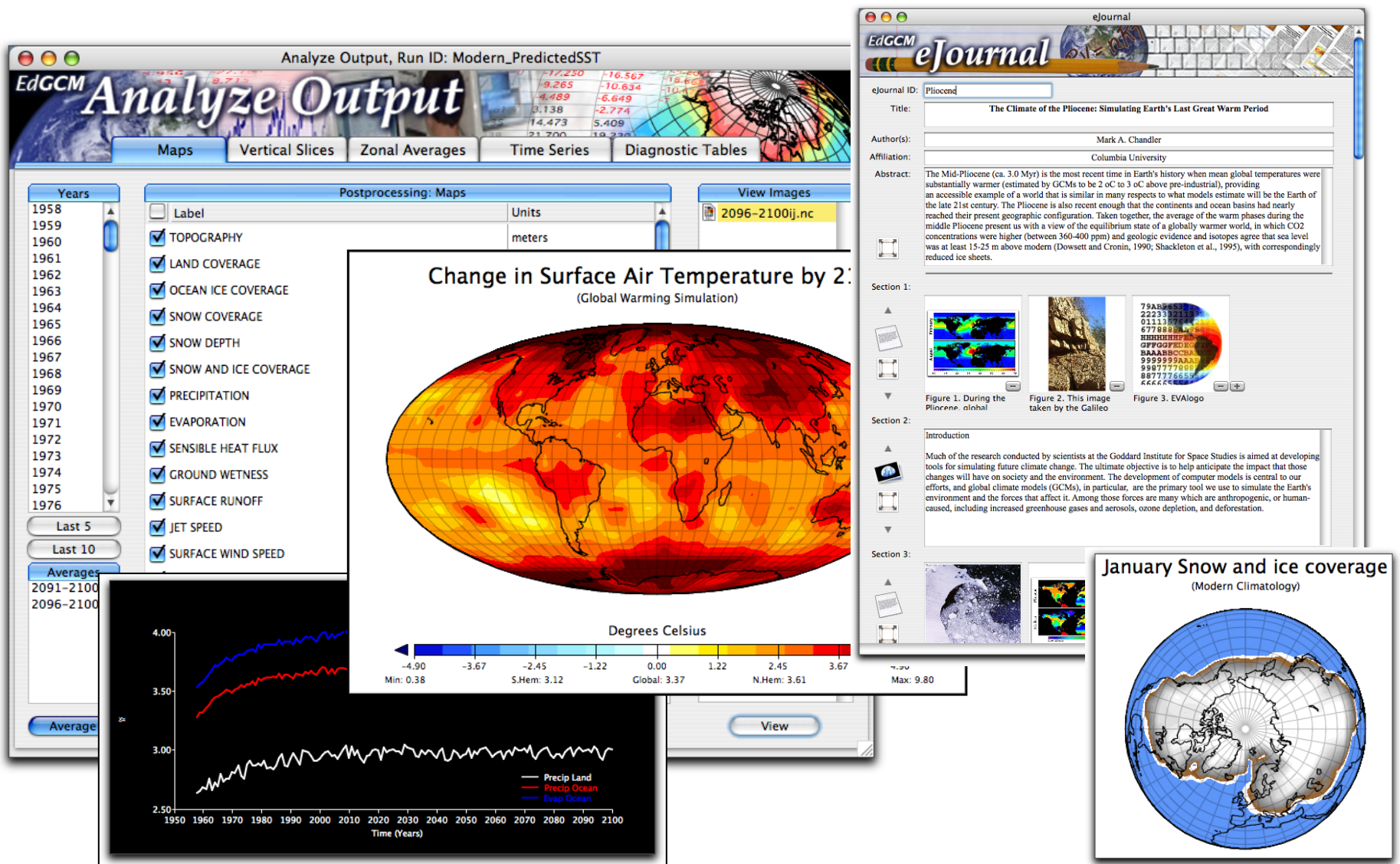
Cleanup: A window for managing simulation files. It includes a 'Selected runs' list (IPCC_A1FI_CO2) and 'Run statistics' (Current used, ACC, Diagnostics, Ocean, PRT, RSF). It also shows 'Disk statistics' (Disk space, Volume, Capacity, Current used, Available).

EdGCM 4D: A window showing a 3D visualization of the Earth's surface, likely representing a simulation result.

Image Browser: A window displaying a series of images related to the simulation, including maps of annual average surface air temperature, difference (anomaly) plots, and maps of annual average surface air temperature for the Modern control run, with 1958 forcings.

EdGCM: Ocean Fluxes: A window for configuring ocean fluxes. It includes sections for Vertical Fluxes, Mixed-layer Temperatures, Ocean Heat Transports, and a 'Generate Restart File' button. It also shows a timeline for the simulation (Start year, End year, RSF year).

Analyze, Visualize and Publish Results



Creating Reports and Publishing

eJournals

eJournal

eJournal ID: Pliocend

The Climate of the Pliocene: Simulating Earth's Last Great Warm

Mark A. Chandler
Columbia University

Abstract: The Mid-Pliocene (ca. 3.0 Myr) is the most recent time in Earth's history when mean global temperatures were substantially warmer (estimated by GCMs to be 2 oC to 3 oC above pre-industrial), providing an accessible example of a world that is similar in many respects to what models estimate will be the Earth of the late 21st century. The Pliocene is also recent enough that the continents and ocean basins had nearly reached their present geographic configuration. Taken together, the average of the warm middle Pliocene presents us with a view of the equilibrium state of a globally warmer world, in which CO₂ concentrations were higher (between 360-400 ppm) and geologic evidence and isotopes agree that sea level was at least 15-25 m above modern (Dowsett and Cronin, 1990; Shackleton et al., 1995), with correspondingly reduced ice sheets.

Section 1:

Figure 1. During the Pliocene, global temperatures, particularly at high latitudes, are believed to have been significantly warmer than today. This figure

Figure 2. This image taken by the Galileo

Figure 3. EVAlogo

Section 2:

Introduction

Much of the research conducted by scientists at the Goddard Institute for Space Studies is aimed at developing tools for simulating future climate change. The ultimate objective is to help anticipate the impact that those changes will have on society and the environment. The development of computer model efforts, and global climate models (GCMs), in particular, are the primary tool we use to environment and the forces that affect it. Among those forces are many which are anthropogenic, or human-caused, including increased greenhouse gases and aerosols, ozone depletion, and deforestation.

Section 3:

Image Libraries

Image Browser: Images 1-16 of 19 images

View: Snowball Earth

Map of annual average surface air temperature

Continent-scale ice sheets have tremendous

This graph shows the increase in the Sun's

Difference map showing the deviation of annual

Map of annual average surface air temperature

Map of annual average snow and ice cover for

Timeline of some key events and intervals in

Advanced radar imaging of sea ice cover in the

The Climate of the Pliocene: Simulating Earth's Last Great Warm Period

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Figure 1: During the Pliocene, global temperatures, particularly at high latitudes, are believed to have been significantly warmer than today. This figure

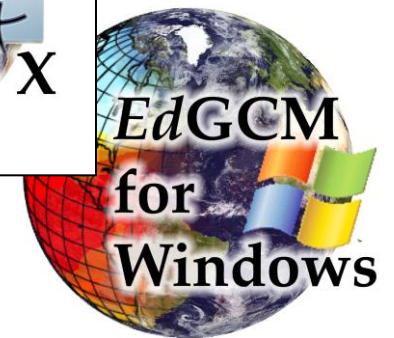
Figure 2: Cap Carbonates overlying glacial diamictite.

Introduction

Much of the research conducted by scientists at the Goddard Institute for Space Studies is aimed at developing tools for simulating future climate change. The ultimate objective is to help anticipate the impact that those changes will have on society and the environment. The development of computer models is central to our efforts, and global climate models (GCMs), in particular, are the primary tool we use to simulate the Earth's environment and the forces that affect it. Among those forces are many which are anthropogenic, or human-caused, including increased greenhouse gases and aerosols, ozone depletion, and deforestation.

Web-based Publishing

The EdGCM Websites



Spotlight on...



EdGCM provides a research-grade be run on a desktop computer. For the same way that actual research knowledgeable about a topic the generation of scientists who will gr

Our goal is to improve the quality access to GCMs, and to provide

EdGCM Forums			
User CP	FAQ	Members List	Calendar
Forum			
Announcements (1 Viewing) Important announcements regarding the EdGCM project and software.			
Support Need help with EdGCM? Post in the appropriate forum below...			
Technical Support (1 Viewing) Help with EdGCM: downloads, installation, interface, disk management, etc.			
Science and Modeling Questions (1 Viewing) Help with climate science and the global climate model.			
EVA - The EdGCM Visualization Application (1 Viewing)			
EdGCM goes to Antarctica by mankoff July 13th, 2007 21:45			
Changed permissions/flags... by mchandler Today 10:26			
Why does the SLP in EdGCM's... by Patrick LEE October 6th, 2007 00:31			
Reinstalling or Updating EVA... by mchandler October 3rd, 2007 23:25			
EdGCM Icon by mchandler April 2nd, 2006 14:06			
Dirt snow by mchandler June 20th, 2007 11:07			
EdGCM in Italy by mchandler December 4th, 2006 20:06			

- Download Software and Materials
- Support and Discussion Forums
- Community and Student Showcases
- Video Tutorials and Manuals

Education Partnerships



University of Wisconsin – Madison
Department of Atmospheric and Oceanic Sciences
Geography Department



Southern University (and LSU) – Baton Rouge, LA
Urban Forestry Program



Dickinson College
Community College Teacher Professional Development



American Museum of Natural History
Seminars in Science, Continuing Education Programs

Columbia University, New York, NY
 University of Wisconsin - Madison
 Rutgers University, Newark, NJ

Macalester College, St. Paul, MN
 Clarkson University, Potsdam, NY
 Indiana University Southeast, New

Madison East High School, M
 Memorial High School, Madi
 Youngstown State University,

100+ Institutions in U.S. using EdGCM

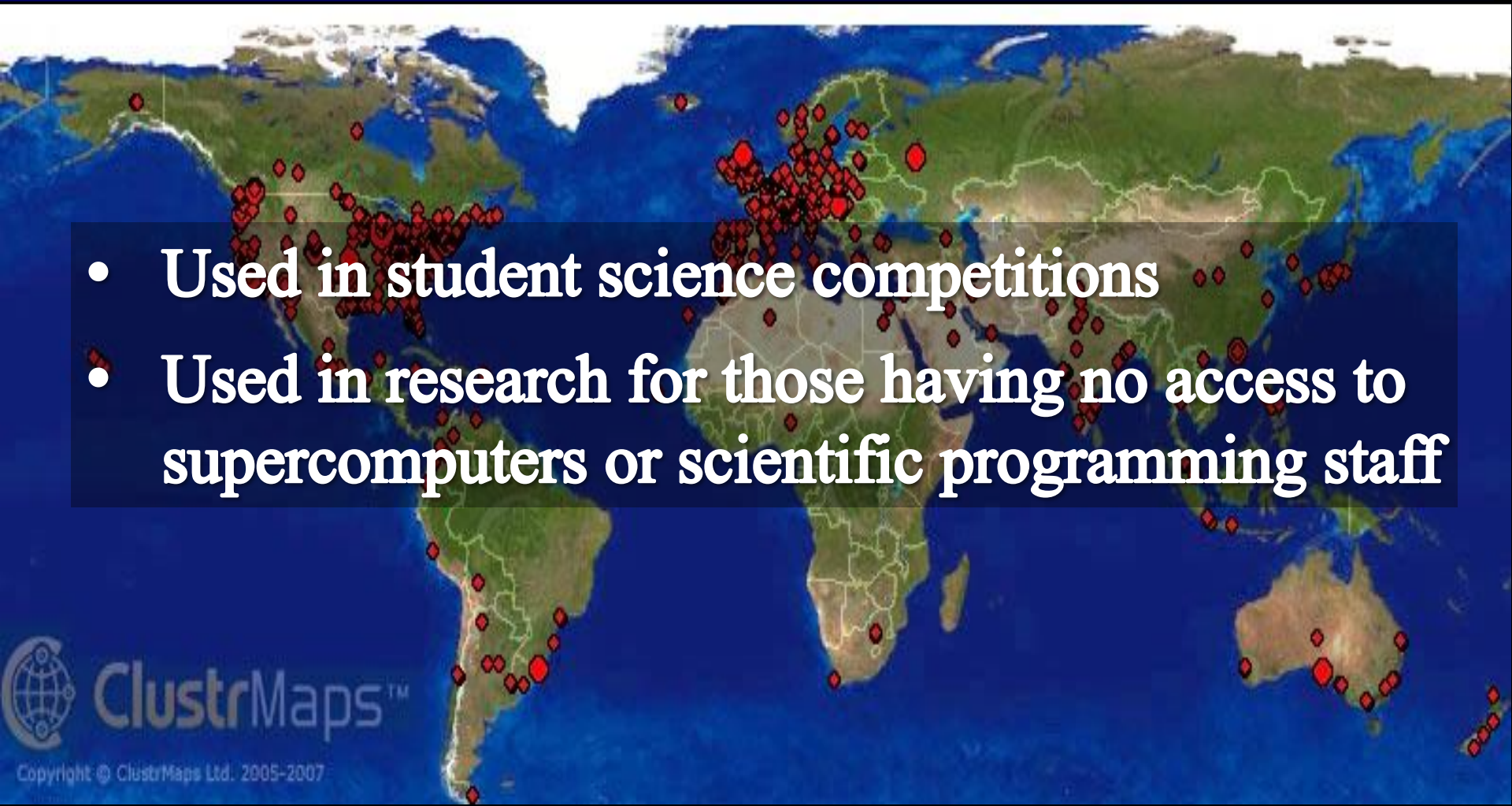


Pleasant, MI

University of California - Riverside,

University of Massachusetts -

Global Interest. Global Need.

- 
- A world map with a blue background and green landmasses. Numerous red diamond markers of varying sizes are scattered across the map, indicating global interest and need. The markers are most densely clustered in North America, Europe, and East Asia, with smaller clusters in South America, Africa, and Australia. A semi-transparent dark blue rectangle is overlaid on the map, containing two bullet points.
- Used in student science competitions
 - Used in research for those having no access to supercomputers or scientific programming staff

Challenges

Keeping up with the pace of cutting edge climate modeling and consumer electronics companies

- Windows 7 and Windows 8
- Mac OS X Lion & Mountain Lion
- EzGCM and WebGCM
- iOS and Android – tablet computing in schools

Educational Global Climate Modeling

The world is in your hands.



- Run a real NASA climate model
- Create your own simulations
- Make maps and plots
- Hundreds of climate variables
- Past or Future climates
- Mac or PC
- <http://edgcm.columbia.edu>

